Where in Europe will hydrogen become competitive first?

Hansen, Anders Chr.

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Where in Europe will hydrogen become competitive first?

by

Anders Christian Hansen

The Department of Environmental, Social and Spatial Change
ENSPAC
Roskilde University

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Abstract

The hydrogen and fuel cell (HFC) technology is expected to be commercially available at some point of time in the period 2015-25. It will, however, not be equally competitive in all regions and countries of Europe at the same time. The paper identifies the regions and countries where the conditions are most favourable for using HFC technology in automotive transport. These conditions include high fuel taxes, significant vehicle tax reductions for HFC vehicles, high car and population density, and a high level of disposable income. Other more local incentives such as road tolls, congestion taxes, and parking fees could be expected to be used in areas where the HFC technology can give a significant contribution to reduction of local air pollution. These regions are shown too.

Acknowledgements:

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Academic disciplines involved:

Energy economics, environmental economics

Keywords:

European regions, member states, fuel taxes, vehicle taxes, car density, hydrogen competitiveness

Address for correspondence:

Anders Chr. Hansen,

Department of Environmental, Social and Spatial Change (ENSPAC),

Roskilde University, P.O. Box 260, DK-4000 Roskilde, DENMARK

Phone:	+45 4674 2000
Direct Phone:	+45 4674 2860
Cell Phone:	+45 6167 0592
E-mail:	anders@ruc.dk

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Factors making hydrogen and fuel cell technology in automotive use competitive

Some of the most important factors for hydrogen and fuel cell (HFC) technology to become cost competitive with the petrol or oil fuelled internal combustion engine (ICE) have been studied in Hansen (2007e), (2007c), (2007a), (2007f), (2007b), (2007d). These factors include the relative fuel prices, including the relative cost of fuel infrastructure, and the relative cost of vehicle ownership. The choice between the two technologies can also be important for societal priorities such as climate stability, clean air, and security of supply. Choosing hydrogen will be important for climate stability and security of energy supply if it is based on non-fossil primary energy and it can be important for clean air in certain areas that are prone to smog formation due to locked air sheds and other circumstances. Member states and regions where these contributions to societal goals are considered important are likely to use tax and fee instruments to further the share of hydrogen and fuel cell technology in the regional or national vehicle fleet.

One of the conclusions in the above mentioned studies was that it is very difficult to predict with some degree of certainty when the HFC technology will become competitive to drive systems based on conventional fuels in automotive transport. It is, however, possible to be more specific about at which oil price HFC technology will become cost competitive. Moreover, it is possible to point at the locations where the zero tail-pipe emission property of the technology will be of highest value to the local communities.

On this background, it is furthermore possible to identify the differences between regions and countries in Europe with respect to these factors and thus get some idea of *where* in Europe HFC technology may become competitive first, when it becomes competitive.

The term *cost* or *market competitiveness* usually refers to the cost of the service provided disregarding taxes and subsidies. This is the case in the above mentioned papers too, but the fact is that in Europe governments intervene heavily first of all with taxes on fuels and vehicles and these taxes are very important for the cost competitiveness to the consumers. Hansen (2007b) showed that if the differences between the US and Europe in fuel taxation prevails, HFC technology will become competitive in Europe a long time before it will in the US.

European governments and regional authorities tax fuels, vehicles, etc. to pursue other societal priorities than simply to ensure affordable mobility. These priorities include environmental goals - such as climate change mitigation and restoring healthy air quality in polluted areas of Europe - and supply security goals - such as limiting dependency of fuels with high risks of supply disruption. They may want to provide incentives for consumers to choose according to the societal priorities.

Therefore, the *societal competitiveness* is also important. It can be defined as the social desirability of consumers choosing one technology rather than another in their purchase decisions. It is not easy to predict how the taxes will be in Europe at the time when HFC technology becomes competitive, but it is possible to identify differences between European regions and countries as to where HFC technology is likely to be able to make a difference to local air pollution.

In the following, we will attempt to locate the areas of Europe where HFC technology is most likely to become competitive first by examining the spatial patterns of fuel taxes, car and population density, income level, and air pollution.

Transport fuel taxes

As mentioned above, Hansen (2007b) concluded that transport fuel taxes are very important as to where hydrogen and fuel cell become economic first because the most attractive feature of the technology is its superior efficiency in using the fuel. The following maps show the fuel tax levels in 2005 in Europe.

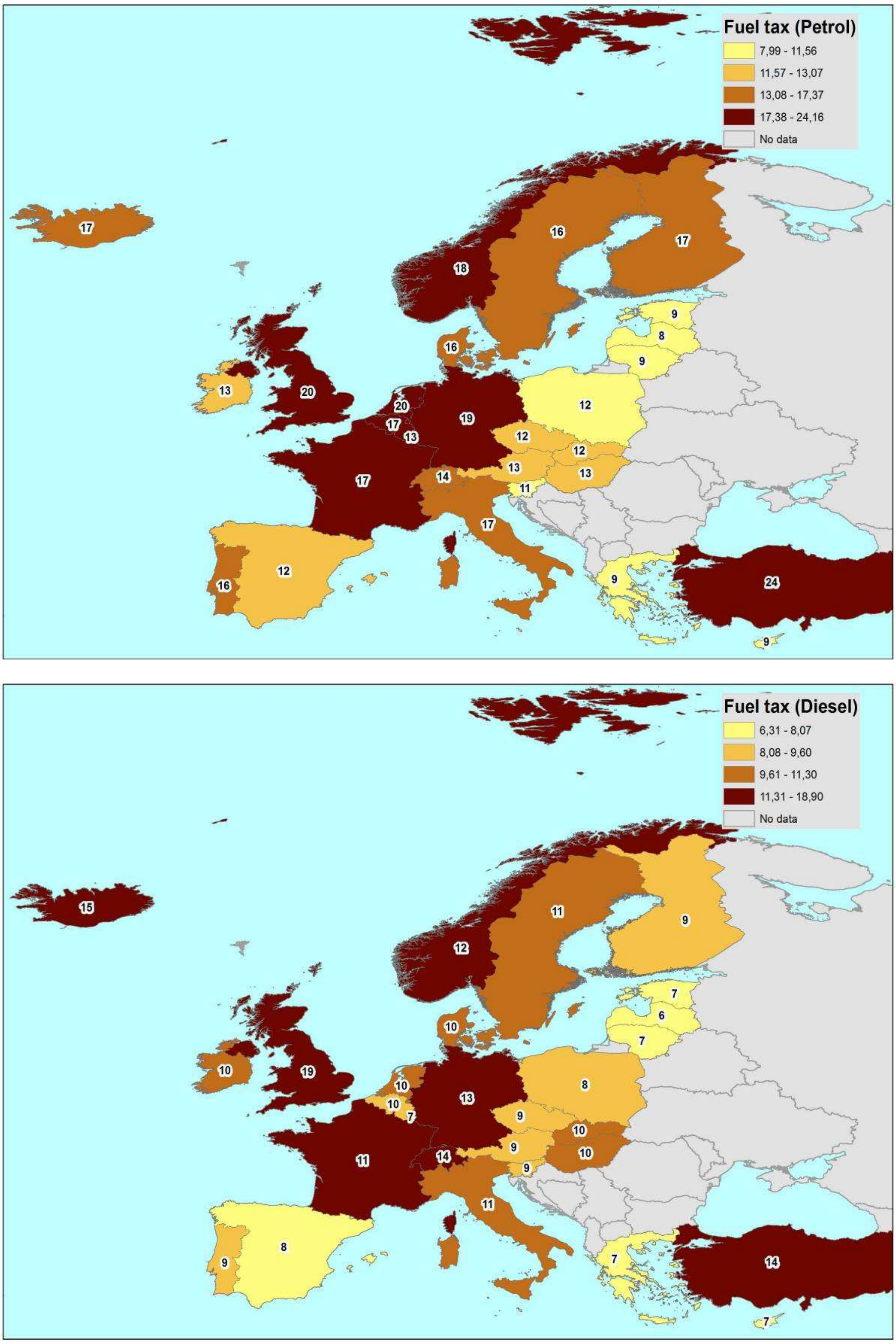


Figure 1. Transport fuel taxes in Europe 2005 (€/GJ).

The “super league” of fuel taxation in Europe (i.e. with the highest average of diesel and petrol taxes) included in 2005 UK, Germany, the Netherlands, France, and Italy. Outside EU Norway, Iceland, and Turkey also belongs to this division. Belgium, Sweden, Finland, Denmark, Portugal, and Ireland (and Switzerland) belongs to the subsequent division.

All European countries have high fuel taxes in a global comparison, but car owners in these countries with the highest fuel taxes will have the largest fuel economy advantage of owning an HFC vehicle.

Car and population density

The capacity utilisation of the infrastructure is always the main determinant of the cost of hydrogen and the period from the establishment of the infrastructure until it reaches full capacity utilisation will be very costly. Thus, advancing rapidly from the first FC vehicle to a full utilisation of infrastructure is therefore critical to keep the “hydrogen-at-pump” cost down.

The regions where such a development is most likely to take place are the regions with the highest vehicle density. The pattern of vehicle density in Europe is shown at the following map.

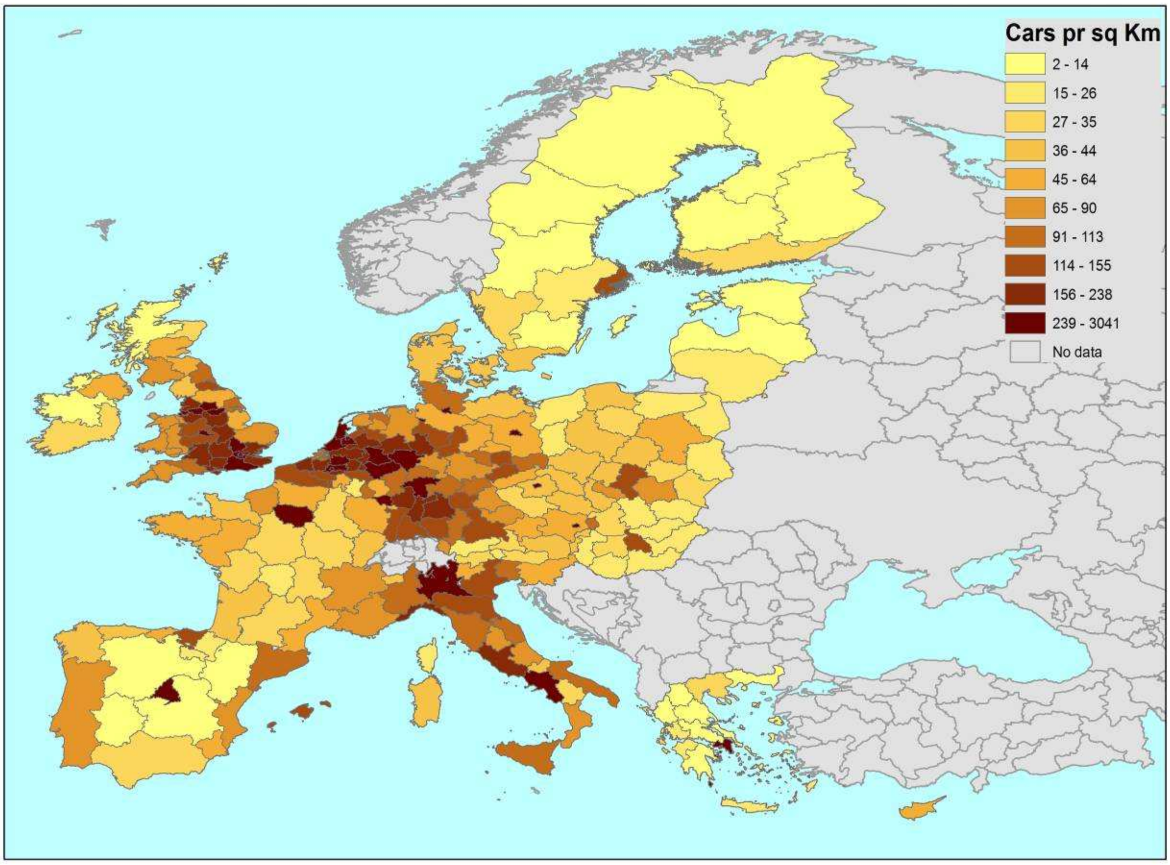


Figure 2. Number of passenger cars per square kilometre in European regions (NUTS2-level)

The “topography” of car density in Europe is characterised by a ridge from Liverpool in England over the Benelux countries to Hannover in Germany and then south to Rome in Italy. Several capitol regions also tower above the European average as to car density.

In these parts of Europe you would expect to be able to expand the utilisation rate of hydrogen infrastructure plants to acceptable levels at an acceptable pace.

Not surprisingly, the areas with the highest car density are to a high degree identical with the most densely populated regions.

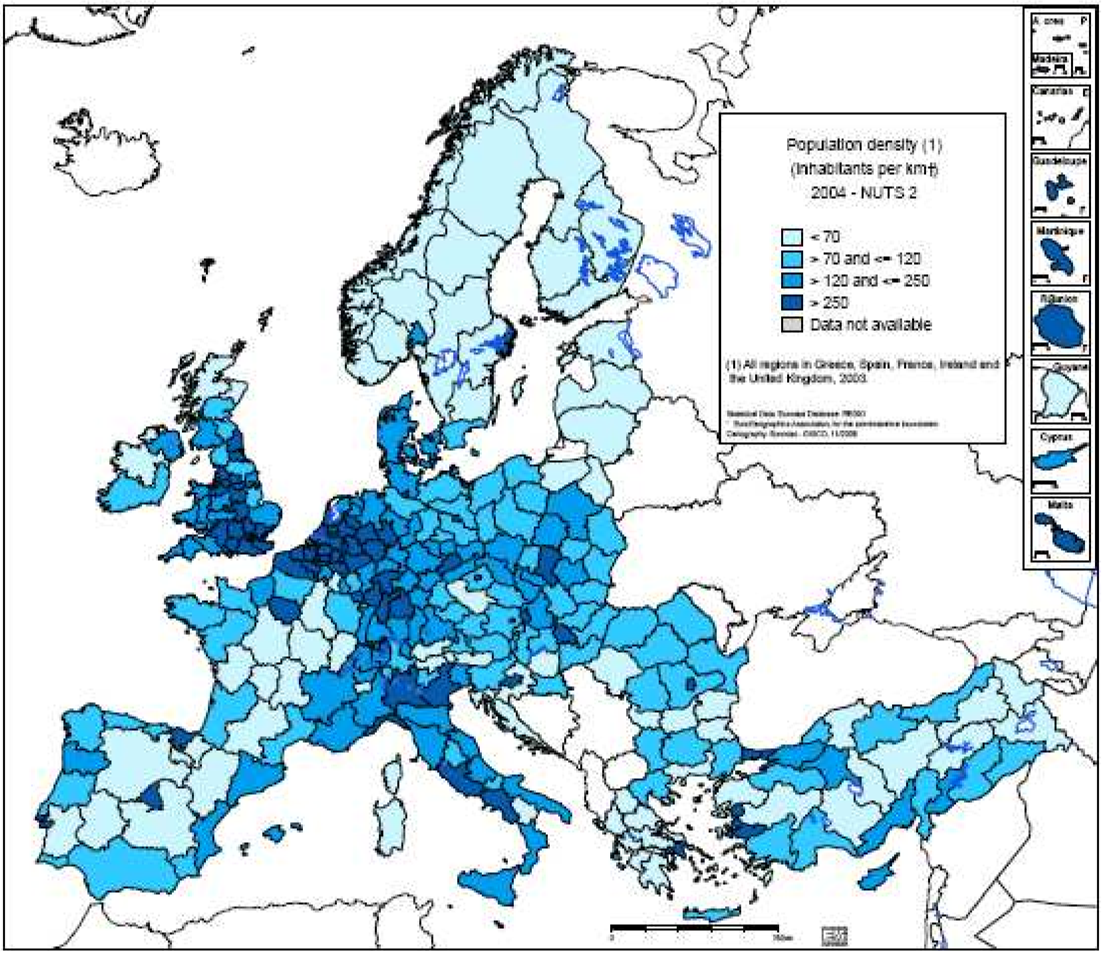


Figure 3. Population density in European regions (NUTS2) 2004 (Inhabitants per sq.km).

The patterns at the map coincides for a large part with the patterns of car density and it is possible that they will do so to an even higher degree about 2020 or when the competitiveness of HFC vehicles becomes a matter of reality.

The differences that exist between the patterns of population density and passenger car density could to a large extent be explained by differences in the level of disposable income and the level of vehicle taxation. These differences, however, could be expected to be less pronounced in 2020.

The following map displays the patterns of disposable income level in Europe. The data are not adjusted for differences in purchasing power.

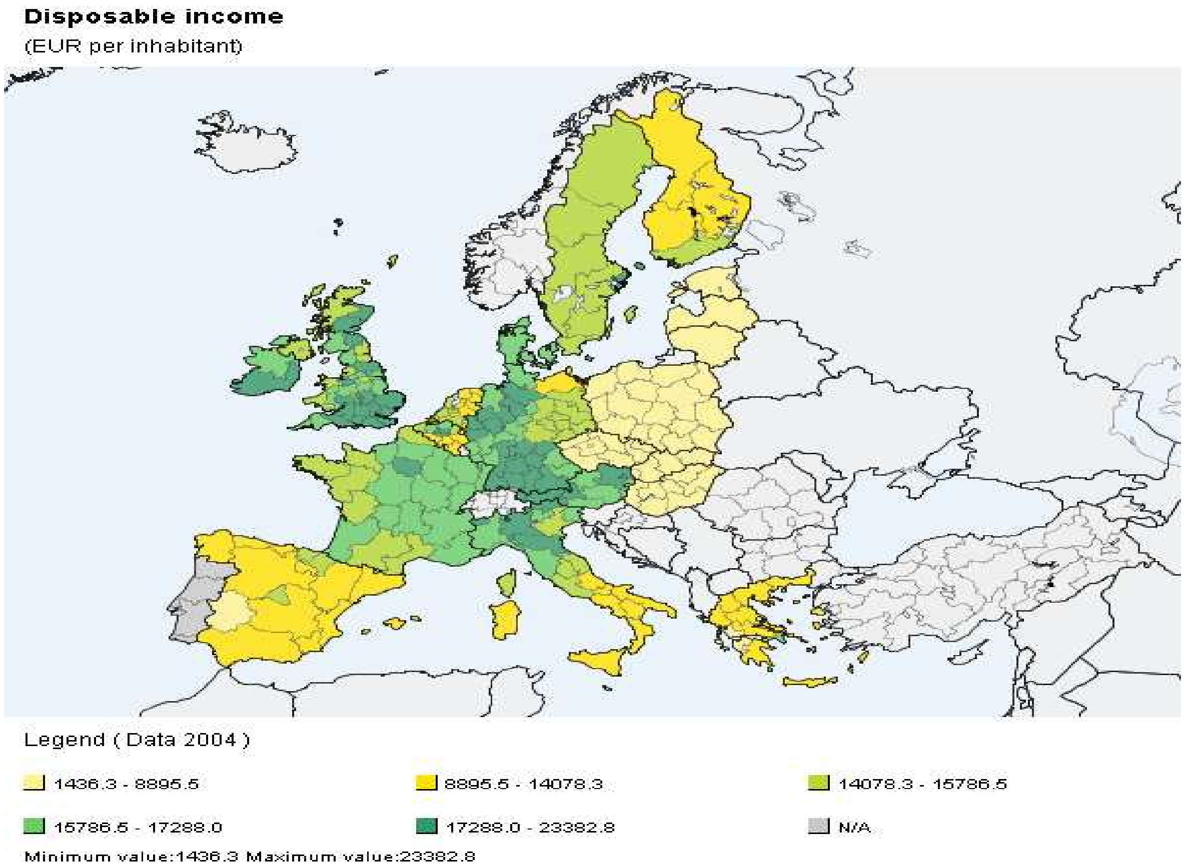
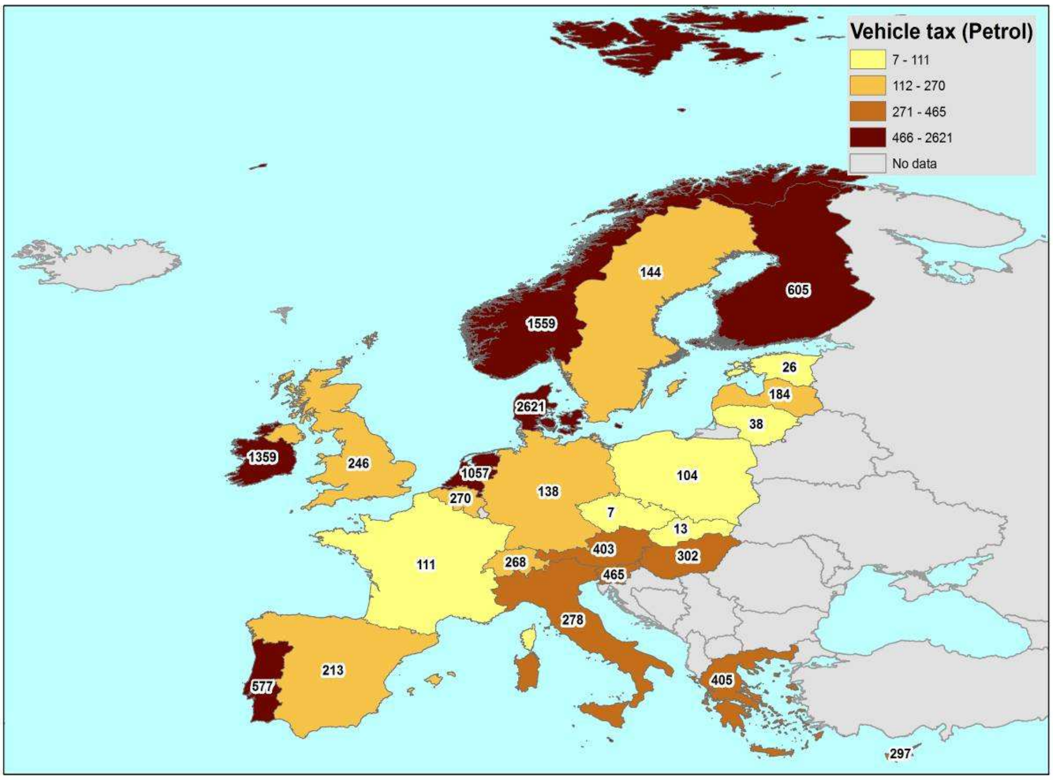


Figure 4. Disposable income in European regions (NUTS2) 2004 (€/inhabitant).

The map shows considerable disparities in the income available for spending on cars. Consumers in the dark green regions do on average command considerably more money than consumers in the yellowish regions do to spend on HFC cars for the novelty, technological excitement, and environmental properties of HFC technology. Whether they actually will, remains to be investigated as the time approaches at which they are given the choice.

The vehicle taxes are also very diverse in Europe. They differ as to whether they are based on vehicle registration (purchase, one time) or circulation (ownership, annual) and whether they are based on engine volume, horse powers, fuel efficiency, purchasing price, or other properties. At the following map they are all converted to the corresponding annual payment and added to an overall annualised vehicle tax.



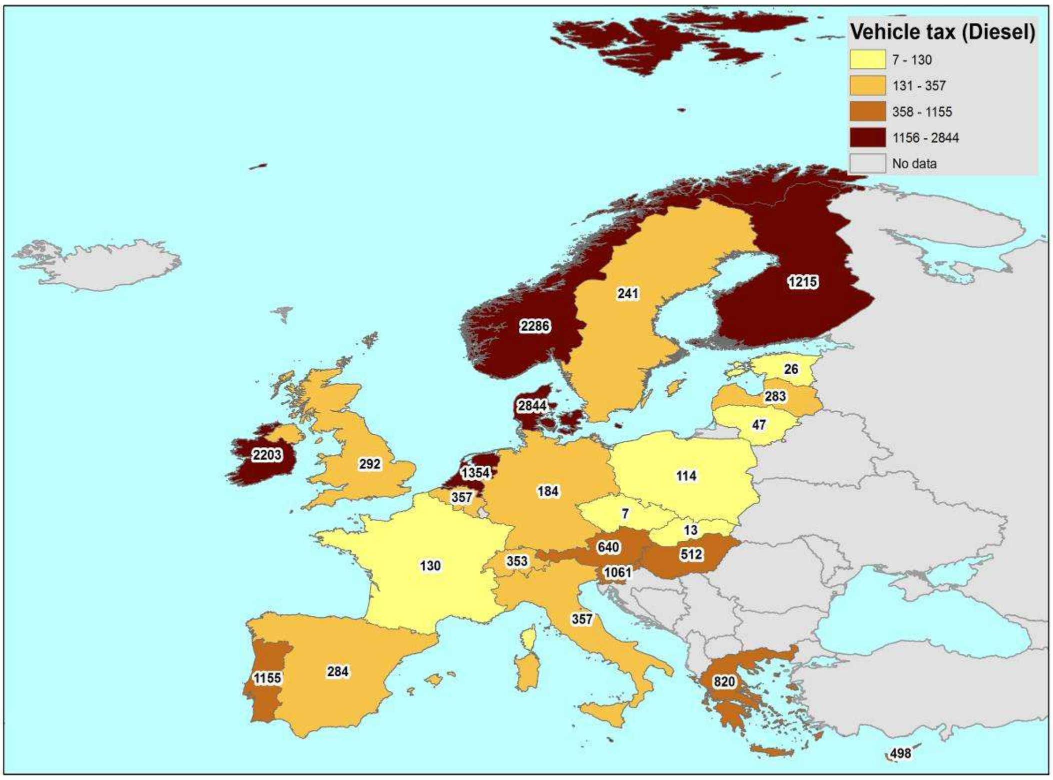


Figure 5. Vehicle taxes in Europe 2005. Golf 1.4 (petrol) and 2.0 SDI (diesel). Converted to annual payments. (€ per year).

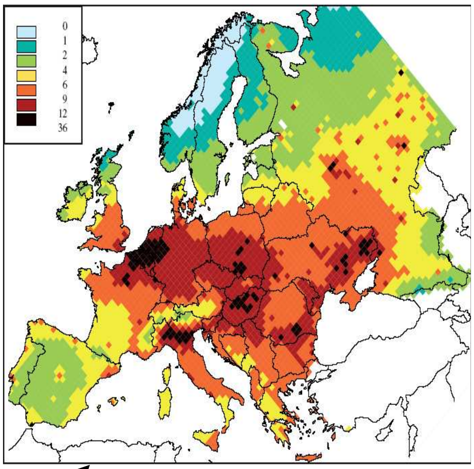
The European vehicle taxes differ even more between countries than the fuel taxes. They are every high in Denmark, Norway, Finland, Ireland, the Netherlands, and Portugal. Most of the countries with high vehicle taxes, however, have already announced that they will exempt fuel cell vehicles fully or partly from vehicle registration taxes and/or circulation taxes. Considering how high the tax rates are in some countries, such exemptions can be the decisive factor that makes fuel cell vehicles competitive. The same effect could in principle be obtained by direct subsidies to the vehicles, but it can be politically more difficult to do.

Other instruments that can be used to further the use of HFC vehicles and other electric vehicles include road tolls, congestion fees, parking fees, and parking opportunities. Rules granting privileges for electric vehicles in these respects are already adopted or in the pipeline in some European cities.

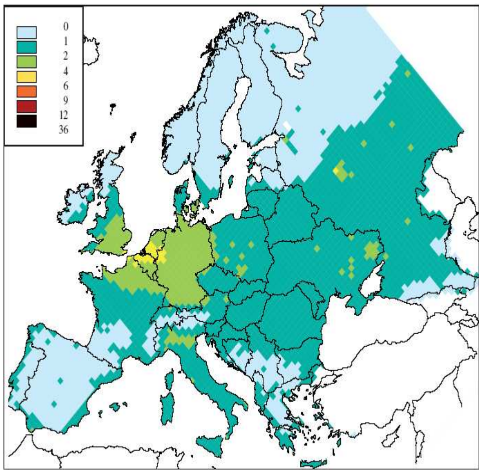
Environmental reasons for local HFC incentives

The potential contribution of the HFC technology in reaching the environmental goals of Europe has been investigated in Hansen (2007a), (2007d). The contribution to reduction of greenhouse gas emissions and local pollutants is modest as long as hydrogen is produced on the basis of natural gas – not to mention coal – without carbon capturing and sequestration. For hydrogen based on renewable energy, however, the contributions can be considerable.

This is important for local air pollution in the areas where local air pollution, primarily from fossil fuel combustion causes smog problems. The maps below display the pollution of smog creating pollutants, particle matter (PM) and tropospheric ozone (O_3).

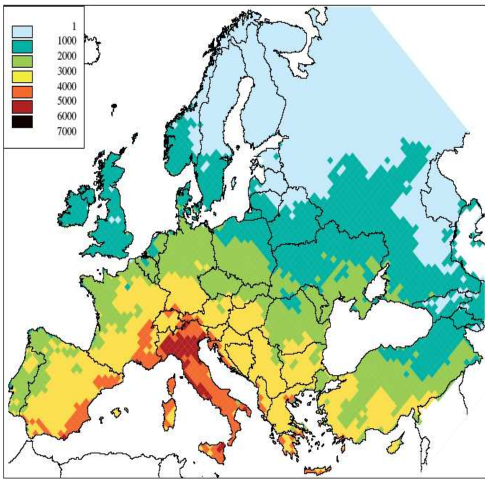


PM 2.5 deaths (loss of statistical life expectancy)

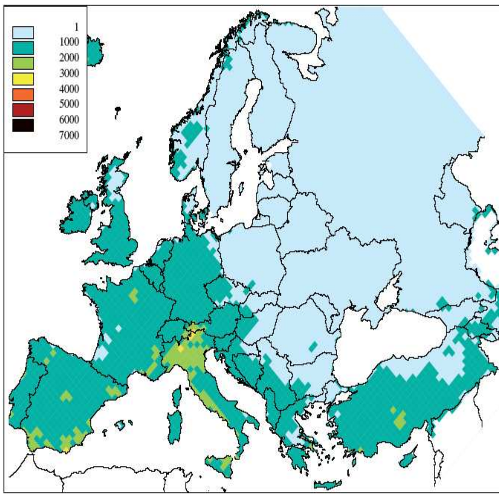


2000

2020 after EU Air Strategy and Maximum Climate Action



O_3 concentration (ppb days)



2000

2020 after EUAir Strategy and Maximum Climate Action

Figure 6. Smog forming pollutants (particulate matter, PM) and tropospheric ozone (O_3) in 2000 and anticipated after implementing the EU Air Strategy in 2020.
Source: Source: EEA (2006)

The maps reflect that with the regulation anticipated in the CAFÉ programme most of the local air pollution will be reduced to acceptable levels in most of Europe.

However, in some regions the pollution is so intense or the renewal of air so slow that even the more optimistic scenarios leave them with too high levels of local air pollution. In these regions, there will be a particular case for using parking fees, parking opportunities, road tolls, and congestion charges to further a rapid replacement of ICE vehicles with electric drive vehicles, i.e., battery electric, hybrid electric, or fuel cell vehicles.

The maps show – not surprisingly – some degree of resemblance of the spatial patterns of pollution intensity to the spatial pattern of car density.

Conclusions

The study of the spatial patterns reveal the UK, Germany, Netherlands, Belgium, Luxembourg, and Italy as the countries where the conditions for cost competitive HFC technology in passenger car transport. In particular, the "topography" of car density in Europe is characterised by a ridge from Liverpool in England over the Benelux countries to Hannover in Germany and then south to Rome in Italy. Several capitol regions also tower above the European average as to car density.

Even where the general conditions of fuel taxation, car density, population density, and average income level are not favourable, hydrogen as a transport fuel can be made favourable by governments determined to advance the HFC technology.

In countries with high levels of vehicle taxation such as Denmark, Norway, Iceland, Finland, Netherlands, Ireland, and Portugal, HFC technology may also be introduced early because of exemptions of such vehicles from taxation. The patterns of air pollution in Europe also indicate that HFC technology may be able to provide an important contribution to air pollution in some of the regions. In these regions, reduced road tolls, congestion taxes or parking fees could play a similar role. Direct or tax subsidies to HFC vehicles and subsidies to the hydrogen infrastructure could be other financial instruments.

Thus, a complete answer to the question of where hydrogen will become competitive to the consumers first requires an answer to the question of where governments are determined to *make* hydrogen competitive.

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